Current status of Landsat 8 surface reflectance algorithm

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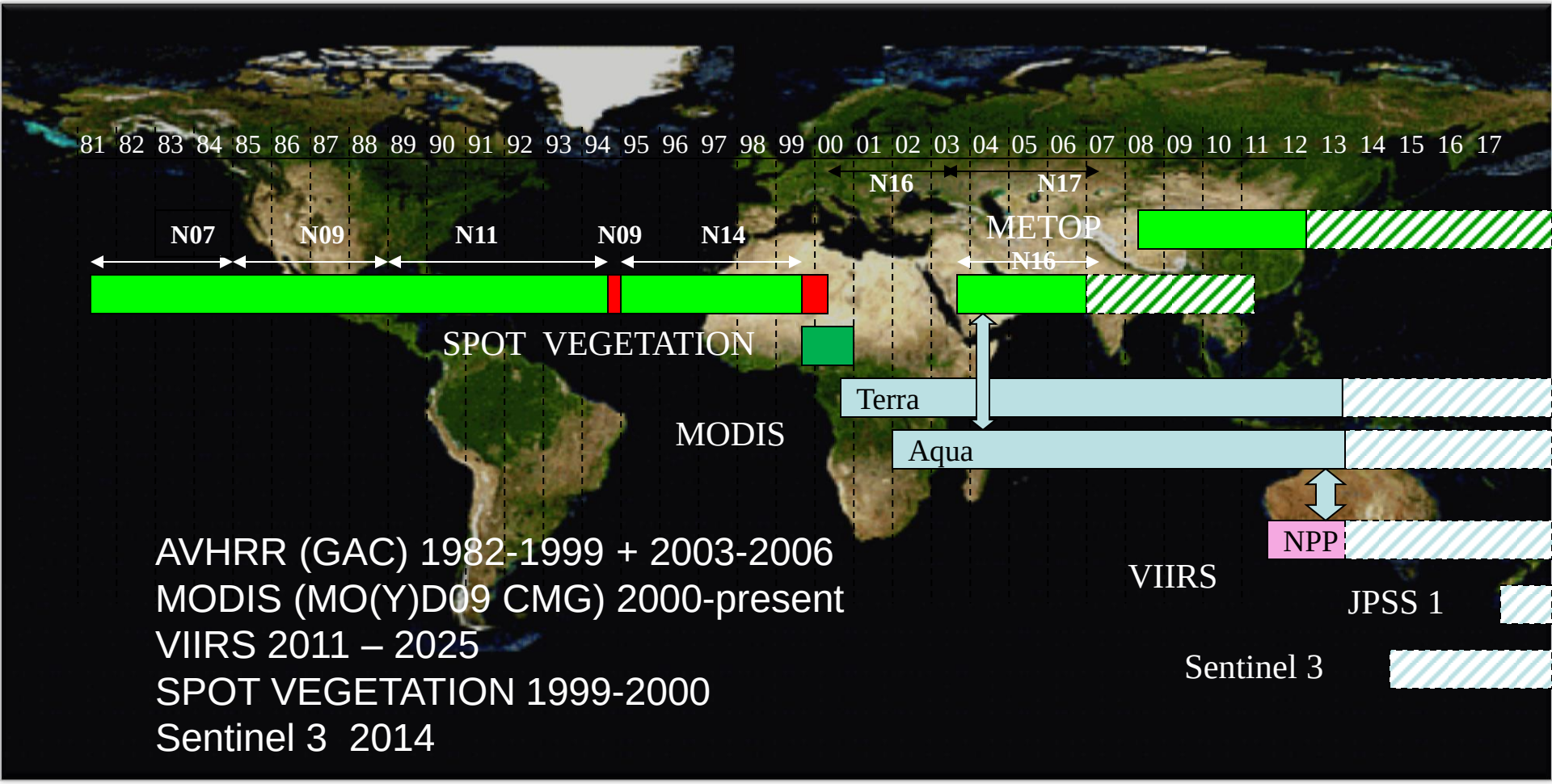
A Land Climate Data Record

Multi instrument/Multi sensor Science Quality Data Records used to quantify trends and changes



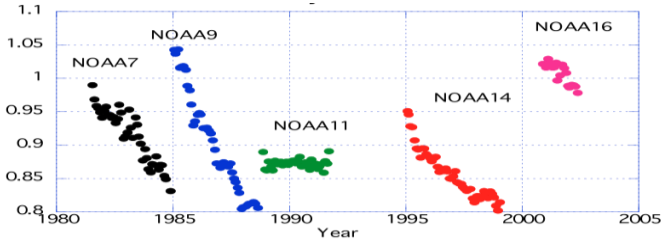
Emphasis on data consistency – characterization rather than degrading/smoothing the data

Land Climate Data Record (Approach)

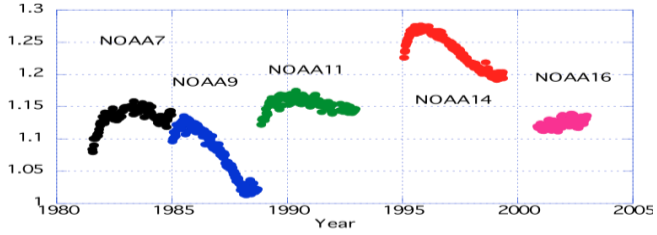
Needs to address geolocation,calibration, atmospheric/BRDF correction issues

CALIBRATION

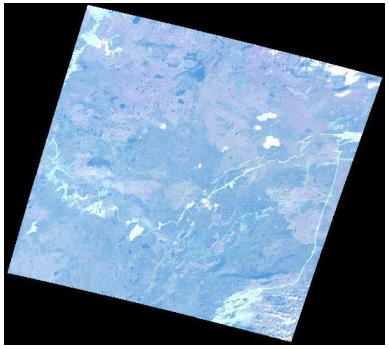
Degradation in channel 1
(from Ocean observations)

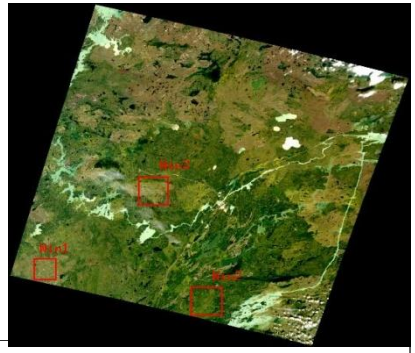


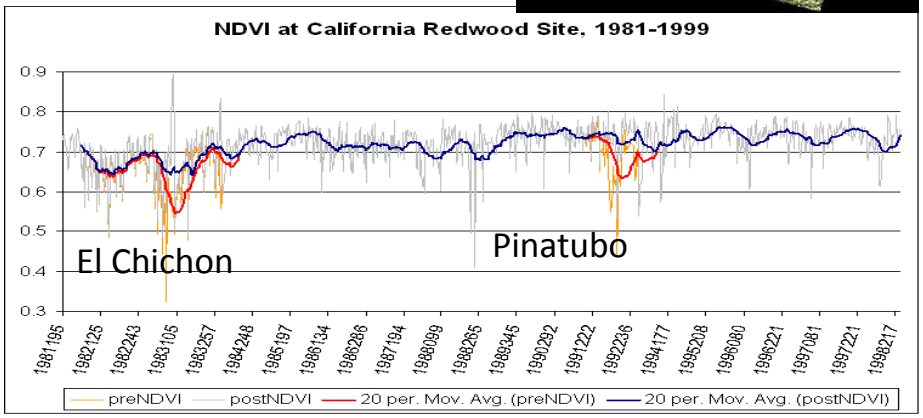
Channel1/Channel2 ratio
(from Clouds observations)



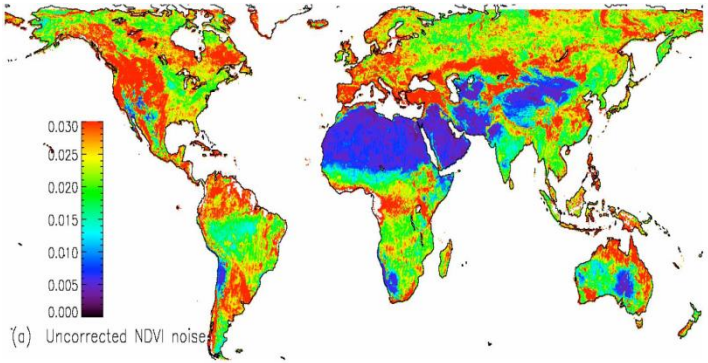
ATMOSPHERIC CORRECTION

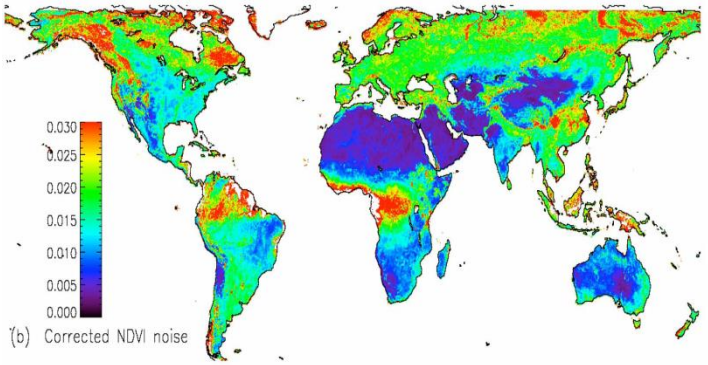


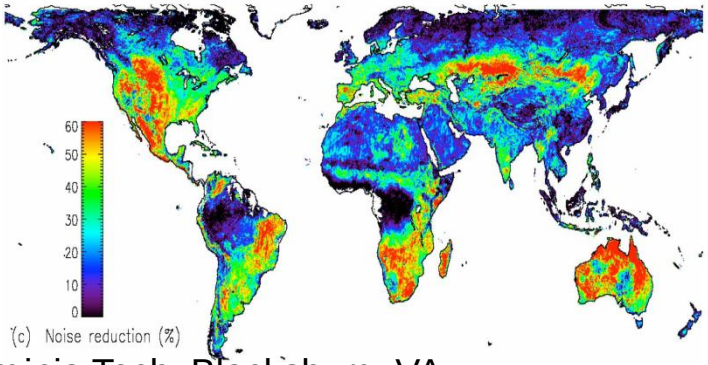




BRDF CORRECTION







Landsat8/OLI Surface Reflectance is largely based on MODIS C6

The MODIS **Collection 6 AC algorithm** relies on

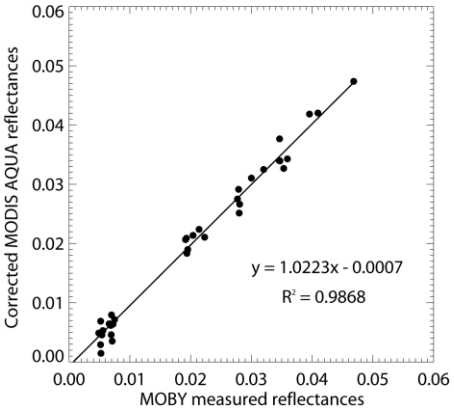
- the use of very accurate (better than 1%) vector radiative transfer modeling of the coupled atmosphere-surface system
- the inversion of key atmospheric parameters (aerosol, water vapor) – ***OLI does not have water vapor inversion band and relies on ancillary water vapor from the MODIS product.***

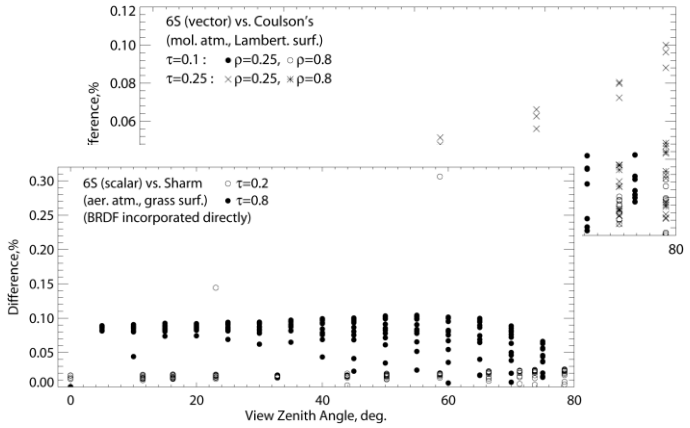
Home page: http://modis-sr.ltdri.org

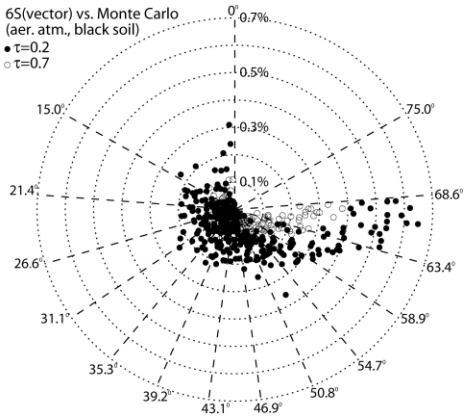
6SV Validation Effort

The complete 6SV validation effort is summarized in three manuscripts:

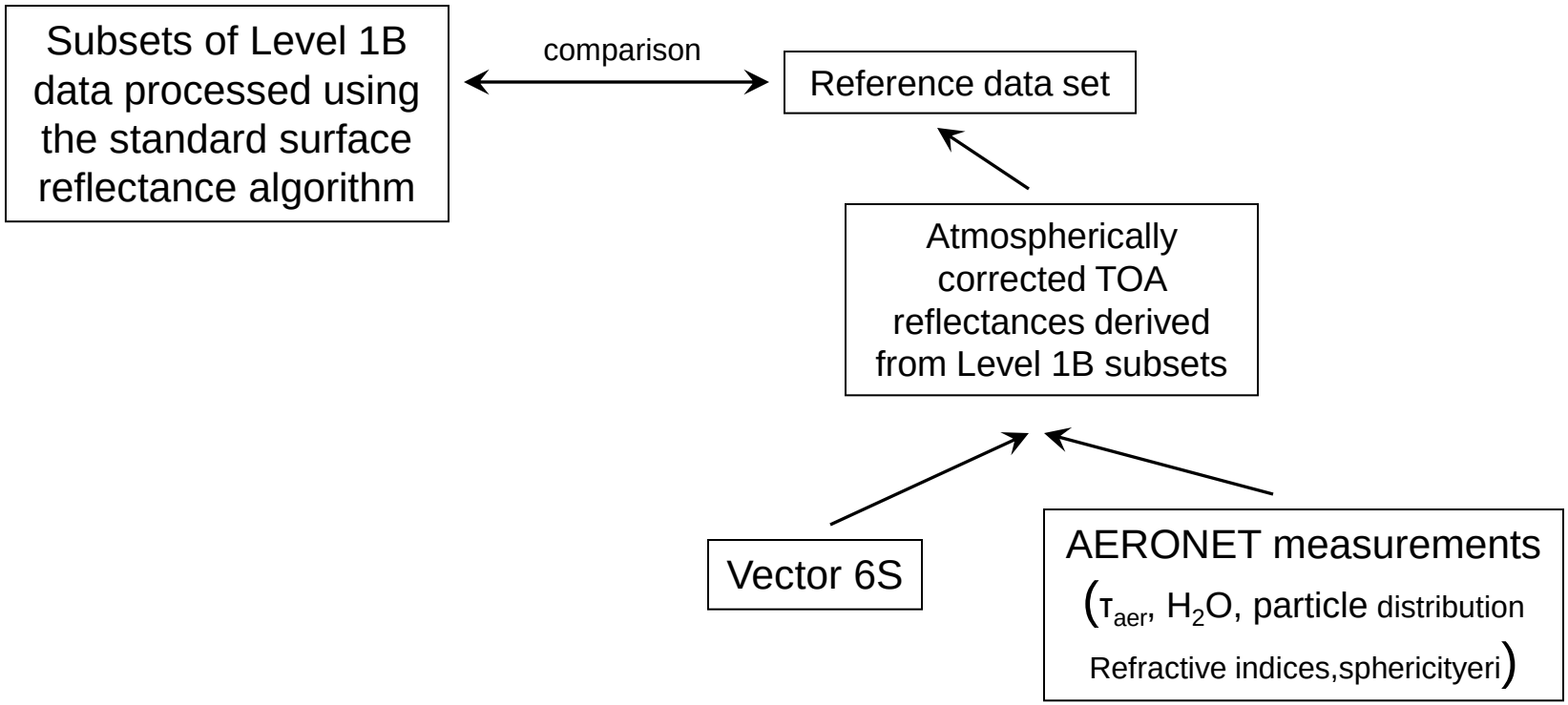
- Kotchenova, S. Y., Vermote, E. F., Matarrese, R., & Klemm Jr, F. J. (2006). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part I: Path radiance. *Applied Optics*, *45*(26), 6762-6774.
- Kotchenova, S. Y., & Vermote, E. F. (2007). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part II. Homogeneous Lambertian and anisotropic surfaces. *Applied Optics*, *46*(20), 4455-4464.
- Kotchenova, S. Y., Vermote, E. F., Levy, R., & Lyapustin, A. (2008). Radiative transfer codes for atmospheric correction and aerosol retrieval: intercomparison study. *Applied Optics*, *47*(13), 2215-2226.







Methodology for evaluating the performance of Landsat8/MODIS



Validation Metrics

- Accuracy (A) = the bias

$$A = \frac{1}{N} \times \sum_{i=1}^{N} \varepsilon_i$$

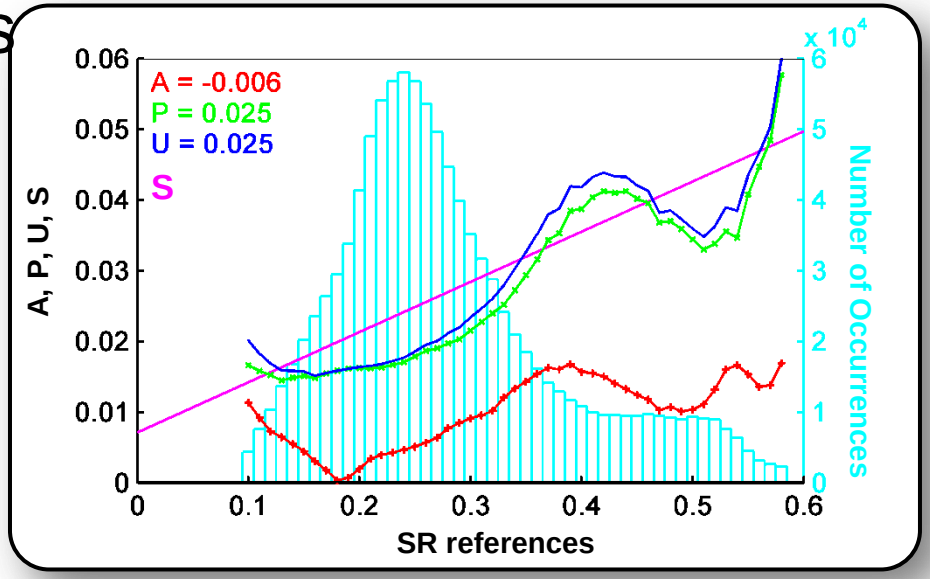
- Precision (P) = the repeatability

$$P = \sqrt{\frac{1}{N-1} \times \sum_{i=1}^{N} (\varepsilon_i - A)^2}$$

- Uncertainty (U) = the actual statistical deviation

$$U = \sqrt{\frac{1}{N} \times \sum_{i=1}^{N} \varepsilon_i^2}$$

$$U^2 = \frac{\sum_{i=1}^{N} \left(\mu_i^e - \mu_i^t - A + A\right)^2}{N} = \frac{N-1}{N} P^2 + A^2$$

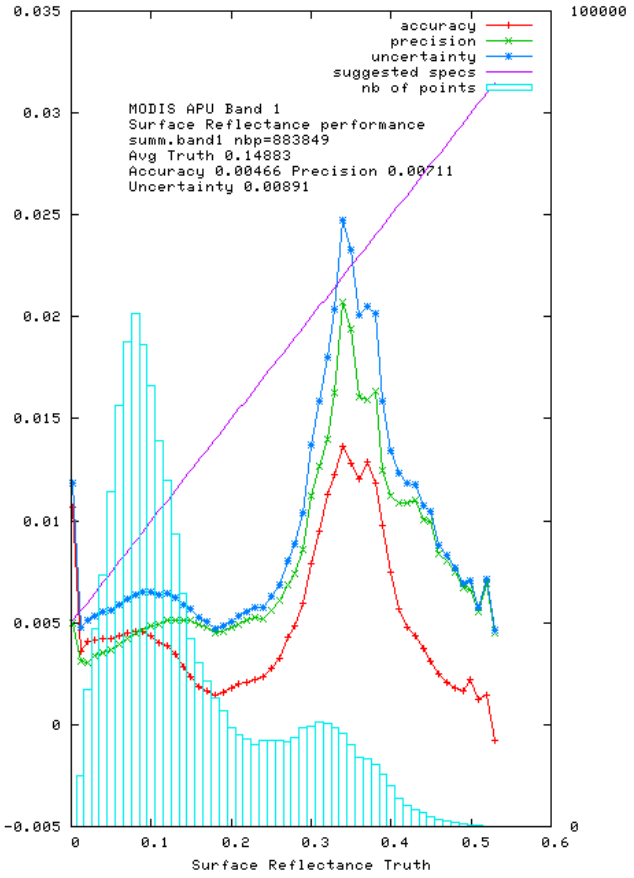


- Specification (S) = Uncertainty requirement

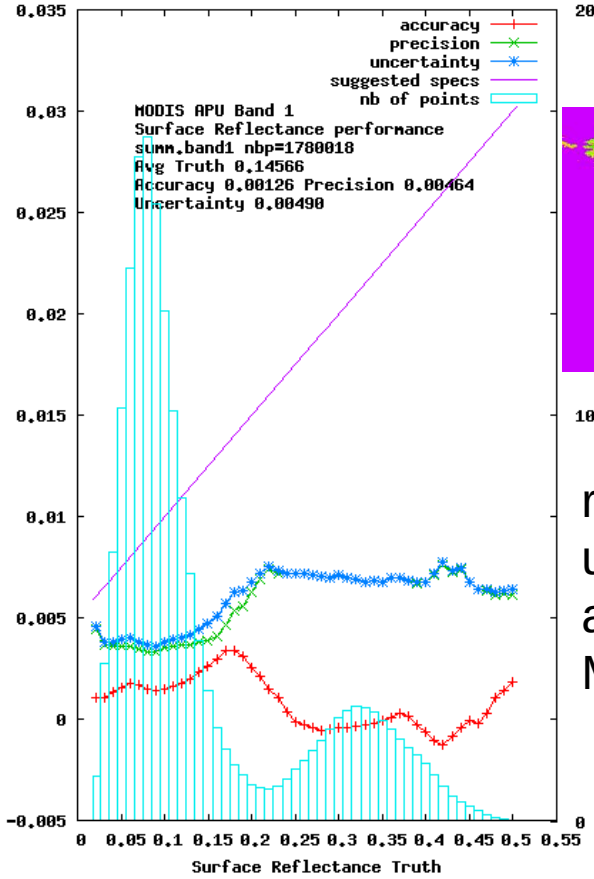
From Vermote and Kotchenova, 2008

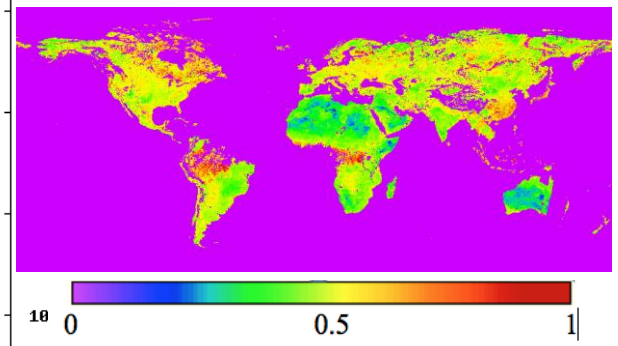
Improving the aerosol retrieval in MODIS collection 6 is well reflected in APU metrics

COLLECTION 5



COLLECTION 6

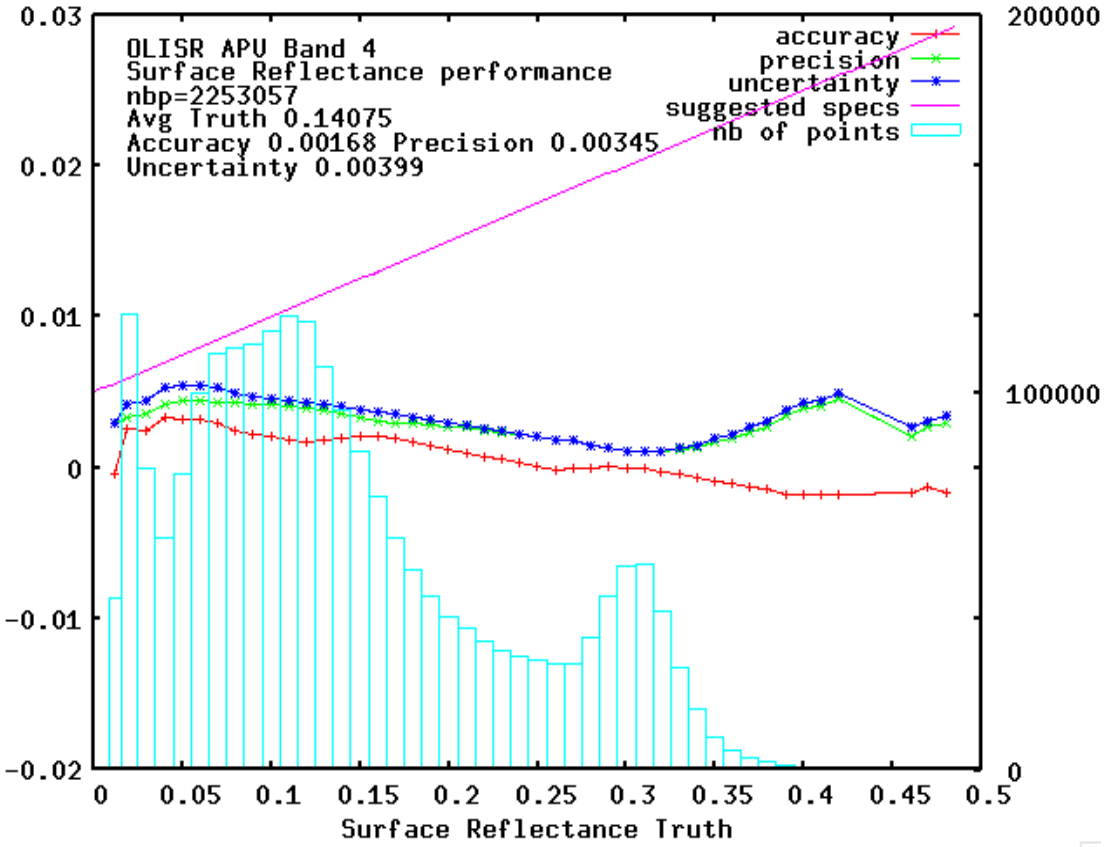




ratio band3/band1 derived using MODIS top of the atmosphere corrected with MISR aerosol optical depth

APU of the surface reflectance in the red band: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in Terra band 1 in the Red, left is collection 5, right is collection 6. Data collected from Terra over 200 AERONET sites from 2000-2009 (collection 5), entire mission (collection 6).

Landsat8/OLI SR product is directly heritage from collection 6 MODIS



The “preliminary” analysis of OLI SR performance in the red band over AERONET is very similar to MODIS Collection 6

Preliminary analysis shows that OLI SR performance are close or better to its precursor Landsat SR

OLI Band	TM LEDAPS (Claverie et al., 2015)			ETM+ LEDAPS (Claverie et al., 2015)			ETM+ LEDAPS (Ju et al. 2012)			ETM+ WELD (Ju et al. 2012)			OLI This work		
	A	P	**U**	A	P	**U**	A	P	**U**	A	P	**U**	A	P	**U**
01													4.8	9.7	**11.**
02	3.7	5.7	**6.8**	6.7	7.7	**10.**	5.3	5.8	**7.9**	6.0	5.2	**7.9**	3.8	7.6	**8.5**
03	0.1	5.4	**5.4**	1.6	6.7	**6.8**	3.9	4.3	**5.8**	3.9	3.4	**5.2**	2.5	4.7	**5.4**
04	0.1	4.1	**4.1**	1.2	6.8	**6.9**	4.2	3.9	**5.7**	3.0	2.6	**4.0**	1.7	3.5	**4.0**
05	3.2	6.1	**6.8**	3.0	6.8	**7.4**	1.0	7.9	**8.0**	4.1	3.9	**5.7**	1.4	2.1	**2.6**
06	3.7	5.9	**7.0**	2.4	4.1	**4.8**	5.6	4.9	**7.4**	1.5	1.5	**2.1**	0.4	1.0	**1.1**
07	3.8	4.5	**5.9**	4.3	4.6	**6.3**	5.1	5.1	**7.2**	1.6	1.6	**2.3**	1.5	2.6	**3.6**

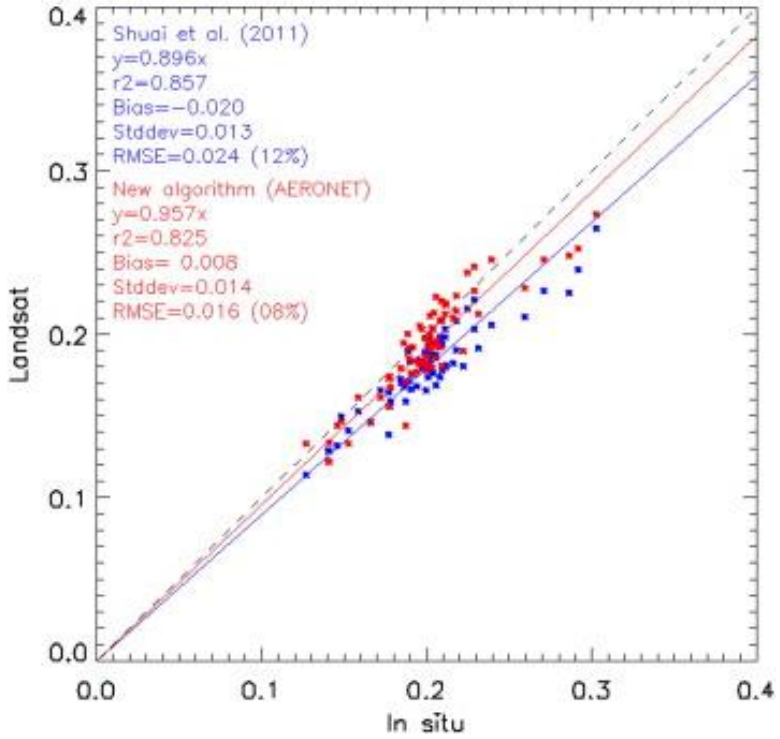
OLI surface reflectance APU scores expressed in 10^{-3} reflectance (compared to TM and ETM+ surface reflectance APU by Claverie et al. (2015) over AERONET Site and Ju et al., 2012 analysis for WELD and LEDAPS algorithm . Band number corresponds to OLI band number designation and equivalent TM/ETM+ bands were reported.

This is confirmed by comparison with MODIS

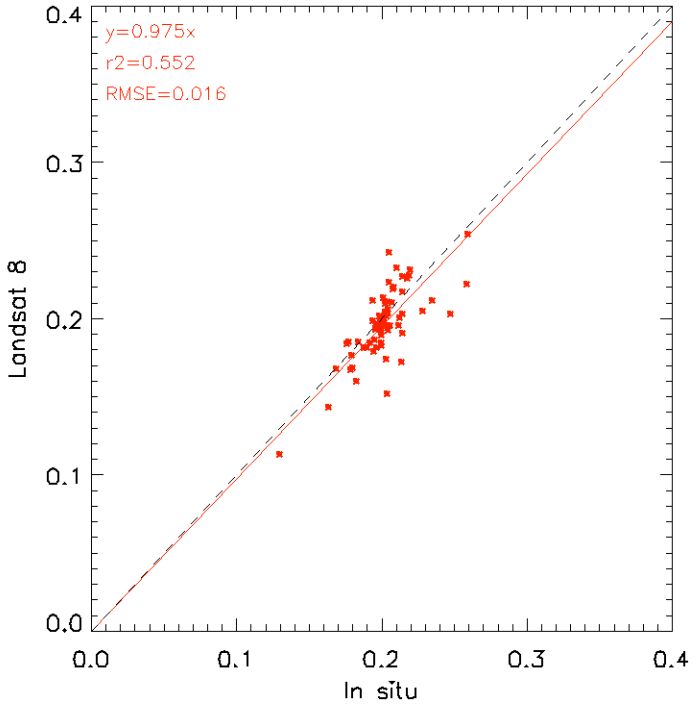
OLI Band	TM LEDAPS (Claverie et al., 2015)			ETM+ LEDAPS (Claverie et al., 2015)			OLI This work		
	A	P	**U**	A	P	**U**	A	P	**U**
2	7	9	**11**	9	7	**12**	2	6	**6**
3	1	9	**9**	6	9	**11**	3	6	**7**
4	9	10	**14**	1	9	**9**	1	6	**6**
5	5	17	**17**	3	14	**15**	2	12	**12**
7	1	14	**14**	5	15	**16**	9	11	**14**

OLI surface reflectance APU scores expressed in 10^{-3} reflectance (compared to TM and ETM+ surface reflectance APU by Claverie et al. (2015) using Aqua MODIS BRDF and spectrally adjusted surface reflectance CMG product as reference, the OLI surface reflectance was aggregated over the CMG. Band number corresponds to OLI band number designation and equivalent TM/ETM+ bands were reported.

The Landsat8/OLI shortwave albedo is also better than its precursors



Validation of Landsat (5/7) Albedo derived by Shuai et al. (2011) and Franch et al. (2014). Note that Franch used AERONET data to improve the surface reflectance of the LEDAPS reflectance product used as input. (From Franch et al. 2014.)



Same as left side but for Landsat8 Albedo, no AERONET data were used to improve the surface reflectance product

Conclusions

- Surface reflectance (SR) algorithm is mature and pathway toward validation.
- Algorithm is generic and tied to documented validated radiative transfer code so the accuracy is traceable enabling error budget.
- The use of BRDF correction enables easy cross-comparison of different sensors (MODIS,VIIRS,AVHRR, LDCM, Landsat, Sentinel 2 ,Sentinel 3…)
- AERONET is central to SR validation and a “standard” protocol for its use to be defined (CEOS CVWG initiative)